Testing the effect of different enzyme blends on increasing the biogas yield of straw and digested manure fibers

Njoku, Stephen Ikechukwu; Jurado, Esperanza; Malmgren-Hansen, Bjørn; Kragelund, Caroline; Ruiz, Begoña; Uellendahl, Hinrich

Publication date:
2014

Document Version
Accepted author manuscript, peer reviewed version

Testing the effect of different enzyme blends on increasing the biogas yield of straw and digested manure fibers

S.I. Njoku[1], E. Jurado[1], B. Malmgren-Hansen[2], C. Kragelund[2], B. Ruiz[3] and Hinrich Uellendahl[1]*

[1] Section for Sustainable Biotechnology, Aalborg University Copenhagen, A.C. Meyers Vænge 15, DK-2450 Copenhagen, Denmark

[2] Danish Technological Institute, Kongsvang Allé 29, DK-8000 Aarhus C, Denmark

[3] ainia centro tecnológico, Parque Tecnológico de Valencia c. Benjamin Franklin 5-11, E-46980 Paterna (Valencia), Spain

*Corresponding author, ph +45 9940 2585, E-mail address: **hu@bio.aau.dk**

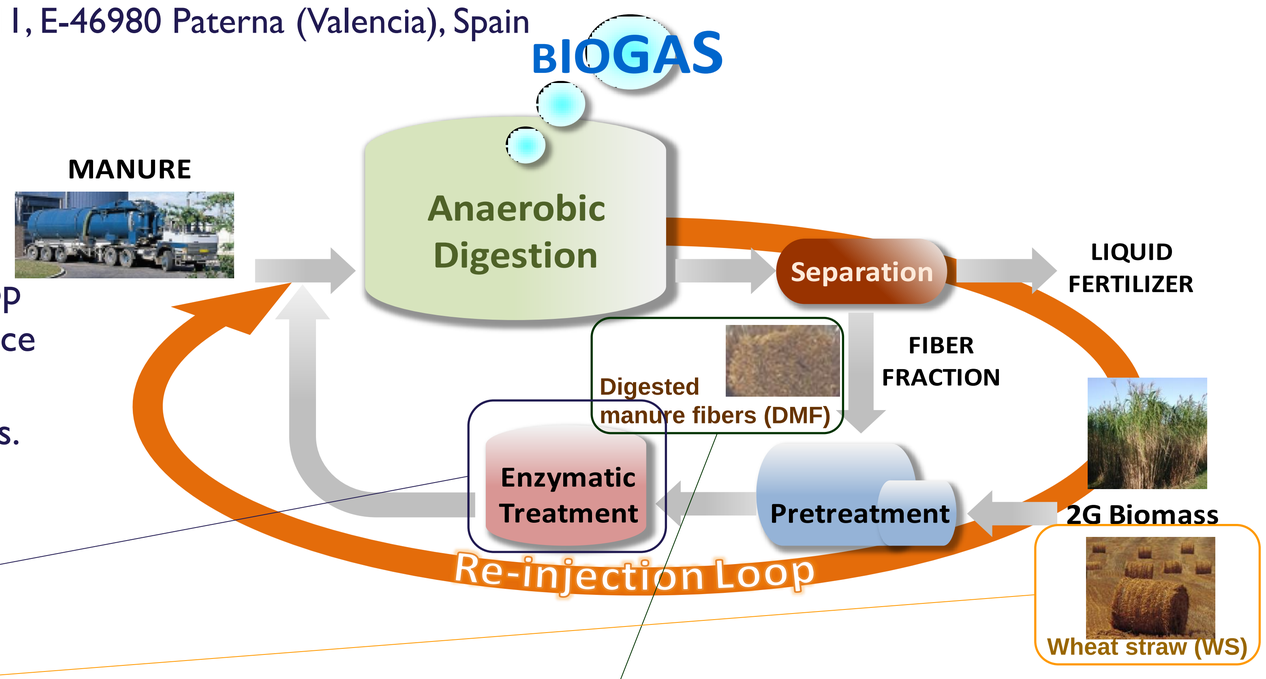
AALBORG UNIVERSITY COPENHAGEN

sustainablebiotechnology.aau.dk

The Re-Injection Loop Concept

In this study, enzymatic treatment was tested to increase the biogas yield of wheat straw (WS) and digested manure fibers (DMF) in the Re-Injection Loop Concept, which combines anaerobic digestion with solid separation to enhance the biogas yield per ton of manure by:

1. Digestion of the easily degradable fraction of manure in the biogas process.
2. Separation of the residual recalcitrant digested fiber fraction project.
3. Ultrasound and/or enzymatic treatment of the digested fiber fraction.
4. Recirculation of the treated fiber fraction into the reactor.



Enzymatic Treatment of WS and DMF

- All tests were conducted in batch tests as separate enzymatic hydrolysis prior to the anaerobic digestion (AD) process. The enzymatic hydrolysis (EH) was performed at the following conditions: T = 50°C, t = 0.5/1.0/72 h, dosage = 0.1/2.5/5.0% g-enzyme/g-TS, 10% TS, pH (adjusted) = pH 5/7, pH (non adjusted) = pH > 8
- **The following enzyme blends were tested:**

Enzyme	Activity	pH range	Temp range (°C)
NZ-P	Protease	8.0-10.0	60-70
ES-C5000P	Neutral cellulase	6.5-8.5	50-70
ES-CX15K	Cellulase and endo-xylanase	2.5-7.0	40-70
NZ-Cat	Catalase	N/D	N/D
NZ-CBG	Cellulase	4.5-6.0	40-55
ES-HC	Endo-xylanase	5.0-8.0	50-80
NZ-CBG1	Cellulase	4.0-6.0	50
ES-C-LA	β- glucanase & endo-cellulase	4.5-6.0	40-50
NZ-X	Xylanase	4.5-6.1	50-70
NZ-BG	β-glucanase	5.0-7.0	50-65
ES-CX900T	Cellulase + xylanase	6.5-8.0	50-70
ES-3000L	Cellulase	4.0-7.0	30-60
ES-8000P	Cellulase	4.5-6.5	50-60

NZ: enzyme blend from Novozymes A/S, ES: enzyme blend from EnzymeSupplies Ltd.

- The subsequent biomethane potential (BMP) tests were performed at 37°C for 60 days. The inoculum used was taken from Hashøj biogas plant, Denmark, treating manure and industrial organic waste.

- **Screening of the different enzymes (50°C, pH 5.0, 72h) on WS** showed an increasing effect on the BMP mainly for enzyme blends containing both cellulase and xylanase activity:

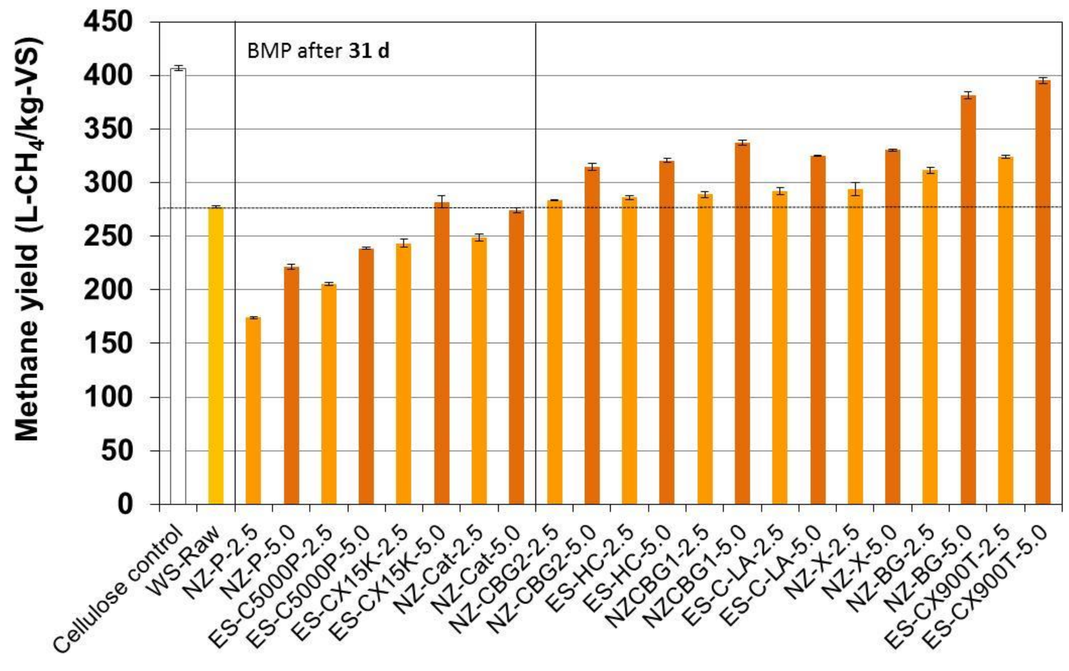


Fig.1 BMP of WS using different enzyme blends in 2.5/5.0% g-enz/g-TS compared to raw WS (------)

- **EH (50°C, pH 7.0/5.0, 0.5/72h) using the best performing and low cost enzyme blends (CX900T/3000L) at low dosage (0.1% g-enzyme/g-TS)** had an increasing effect mainly on the BMP of **DMF**, while the effect on WS was only limited:

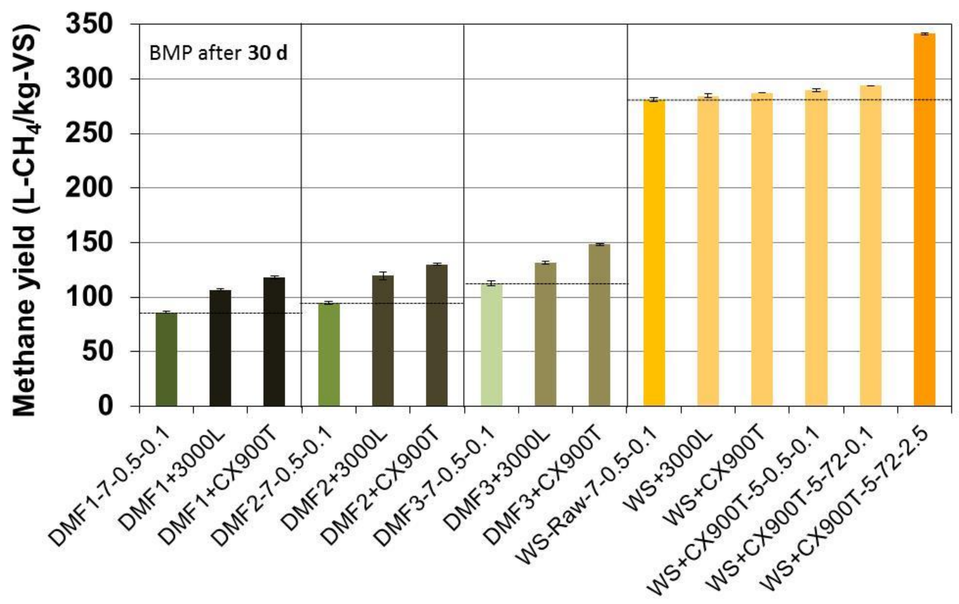


Fig. 2 Effect of enzyme addition on BMP of DMF from 3 different biogas plants (DMF1-3) and of WS

- **EH with no pH adjustment (pH > 8) and 0.1% dosage** showed an increasing effect of the enzyme addition (8000P) compared to treating **DMF** at 42/50°C without enzymes only for 72h of EH:

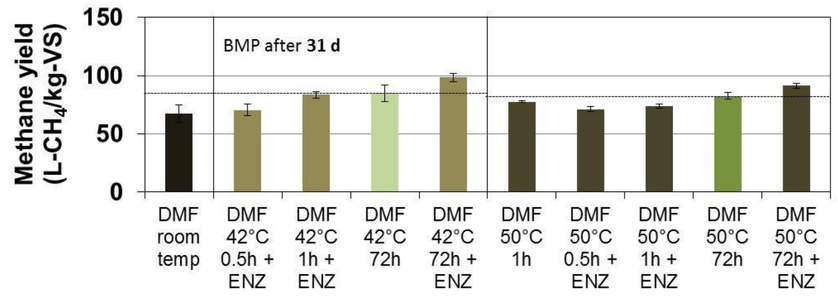


Fig. 3 BMP of DMF after treatment at 42/50°C with and without enzyme addition (for 72h ------)

Conclusions

- Addition of combined cellulase and xylanase activity showed highest effect to enhance the intrinsic hydrolytic activity of the AD process
- The relative effect of enzyme addition was higher for DMF with low BMP
- pH adjustment to pH < 7 showed higher effect of the enzyme addition

Acknowledgements

Enzyme blends were supplied by Novozymes A/S, Bagsværd, Denmark, and EnzymeSupplies Ltd, Oxford, UK. The EU project BIOMAN is funded by the European Union's Seventh Framework Programme managed by REA - Research Executive Agency: http://ec.europa.eu/research/rea (FP7/2007-2013) under grant agreement no. FP7-SME-2012, 315664, "BIOMAN". www.bioman.dti.dk

SEVENTH FRAMEWORK PROGRAMME